Residual nuclide production from iron, lead, and uranium by neutron-induced reactions up to 180 MeV

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Within the HINDAS project, activation experiments with quasi mono-energetic neutrons were performed at the neutron beam lines at The Svedberg Laboratory (TSL), University Uppsala / Sweden and the Universite Catholique de Louvain La Neuve (UCL) / Belgium in order to determine excitation functions for the production of residual radionuclides from a variety of target elements. A total of 10 activation experiments covered proton energies between 36.4 MeV and 178.8 MeV. Residual radionuclides with half-lives between 20 min and 5 years were measured by off-line γ-spectrometry.

At UCL, the absolute neutron fluence was determined with three methods: a proton recoil telescope, a ^{238}U fission ionization chamber, and an NE213 liquid scintillation detector. The spectral fluence was measured with the TOF method, employed with the latter two systems. At TSL, measurements of the neutron peak fluences inside the target stack were carried out by thin-film breakdown counters.

Information on the energy dependence of the neutron spectra in the targets was obtained by modeling the neutron spectra by Monte Carlo techniques using the LAHET/MCNP code system. These transport calculations started either from the experimentally determined neutron spectra (at UCL) or from the systematic of experimentally measured neutron emission spectra of the Li-7(p,n)-reaction. The calculations described the transport of the neutrons into the target stacks and into the individual targets as well the production and transport of secondary particles inside the massive target stacks which cannot be neglected.

Cross sections cannot be directly calculated from these response integrals since the neutrons used are just "quasi mono-energetic" with only about 30 to 50% of the neutrons in the high-energy peak with a width of a few MeV. The neutron cross sections were extracted from production rates determined in a series of irradiation experiments with different neutron energies by unfolding using the STAYS'L formalism starting from guess functions calculated by the ALIPPE code. Here, we report and discuss the results for the target elements Fe, Pb, and U and discuss them in the context of theoretical predictions using the TALYS code.

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